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STRESS INDUCED PHYSIOLOGICAL ALTERATION OF LEAF RELATIVE WATER CONTENT, LEAF PROLINE, AND YIELD OF COTTON UNDER RAINFED AGRO ECOSYSTEM

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ABSTRACT

Field experiments were conducted at the Regional research station, Aruppukottai, Tamil Nadu during rabi season of 2017-18with the test variety SVPR - 2. To study the effect of in-situ water harvesting, stress management practices on physiological parameters of Relative Leaf Water Content (RLWC), Proline and Seed cotton yield of cotton under rain fedagro ecosytems. The experiments were laid out in split plot design replicated thrice. The main plot treatments consisted of different Insitu water harvesting measures viz., Broad bed and furrows, Ridges and furrows and Compartmental bunding. The subplot comprises stress management practices viz., Soil application of push hydrogel @ 5 kg ha^{-1} , Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of 1% KCl, Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of 5% Kaolin, Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1},Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm and Control. The results of this study showed that Broad bed and furrow and Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1} recorded higher RLWC, seed cotton yield and lower values of the Proline content.

KEYWORDS: Relative Water Content, Proline & Cotton

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Original Article

INTRODUCTION

Cotton is a perennial shrub that has been cultivated by man for several thousand years. Cotton fiber is amazingly versatile, whether alone or blended, it out sells all other fibers combined. It is a soft, absorbent, and breathable natural fiber, making it the perfect for clothing. Cotton, truly a miracle fiber, it has been spun, woven, and dyed since ancient times, and it is still the most widely used and preferred fiber for cloth today. At present, India is topmost cotton producing country with 11.88 m ha^{-1}area under production accounting 30 percent of world coverage and 22 percent (351 lakh bales of lint) of the world cotton production with a productivity of 568 kg ha^{-1} (DCD, 2017).Considering this importance of cotton crop different attempts have been made to boost up its production.

The main constraints in rainfed agriculture is the non-adaption of crop management technologies and non availability of moisture during critical stages which causes a decline in crop yield and productivity of cotton. Rain-fed areas can be made productive and profitable by adopting improved technologies for rainwater conservation and harvesting and commensurate agricultural production technologies. Soil management practices are tailored to store

and conserve as much rainfall as possible by reducing runoff and increasing the storage capacity of the soil profile. The most efficient and cheapest way of conserving rainfall is to hold it *in-situ*. In dry land soils *in-situ* moisture conservation ensured higher moisture status in the profile, which provides a favorable environment for plant growth and response to applied nutrients (Singh and Bhan1993).

To increase the moisture availability during critical stages, it is necessary to adopt moisture conservation techniques. The use of ridges and furrows, compartmental bunding and broad bed and furrows (BBF)as*in-situ* soil and water conservation technique, is known to be beneficial for increasing crop yields. The principle behind the different *in-situ* moisture conservation practices is to increase the infiltration by reducing the rate of runoff temporarily impounding the water on the surface of the soil to increase the opportunity time for infiltration and modifying the land configuration for interplot water harvesting (Muthamil selvan*et al*., 2006).

The moisture stress is the primary cause for the yield reduction in Cotton. Water scarcity and rapid environmental changes force us to find a way to conserve the available soil water and properly manage it for efficient crop production. In the way push hydrogel application helps in several ways, by improving soil moisture retention and conserving water in the soil. It holds to secure the crops against moisture stress. Hence, it is very essential to reduce the moisture stress with use of some superabsorbent polymers(SAPs).One such developed product is 'Push hydrogel' which is first successful an indigenous semi-synthetic superabsorbent technology for conserving water and enhancing crop productivity and thereby increases the water use efficiency (IARI, 2012).

And also the PPFM Spray which improves the crop stand to moisture stress. Pink Pigmented Facultative Methylo bacteria (PPFM) release the osmo protectants (sugars and alcohols) on the surface of host plants. This matrix may help to protect the plants from desiccation and high temperatures (Madhaiyan *et al*., 2006). Keeping this in view, an attempt was made to study the effect *in-situ* water harvesting, stress management practices on physiological parameters of Relative Leaf Water Content (RLWC), Proline and Seed cotton yield of cotton under rainfed agro ecosytem.

MATERIALS AND METHODS

A field experiment was conducted at the Regional research station, Aruppukottai, Tamil Nadu during *rabi* season of 2017-18with the test variety SVPR - 2. The experimental location experiences tropical climate with dry summer extending from March to August and winter from August to February. A perusal of 30 years weather data of the site reveals a mean annual rainfall of 830.4 mm distributed in 38 rainy days. The mean annual maximum and minimum temperature ranged from 34.82°C to 22.82°C, respectively. The mean relative humidity ranged from 78.8 to 83.4 per-cent. The experimental site falls under the Southernagro-climatic sub-zone of Tamil Nadu and located at 9°54' N latitude and 78°80' E longitude at an altitude of 147 m above mean sea level. The mean annual rainfall is 786.6 mm in 40 rainy days.

The soil of the experimental fields was medium deep, well drained and vertisol (Type Chromusterts) in texture. The soil low in available nitrogen, low in available phosphorus and high available potassium. All package of practices were carried out as per the recommendation of CPG, 2012. The experiment was laid out in Split-plot design, replicated thrice with test variety SVPR 2.

The main-plot treatments consisted ofdifferent*In-situ* water harvesting measures*viz.*,Broad bed and furrows, Ridges and furrows and Compartmental bunding. The subplot comprises with stress management practices*viz.*,Soil application of push hydrogel @ 5 kg ha^{-1} ,Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of 1% KCl , Soil

application of pushhydrogel @ 5 kg ha^{-1} + foliar spray of 5% Kaolin, Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1},Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm and Control.

The observations were recorded in the five fully expanded leaves of the treatment plots which is of the canopy fully exposed to sunlight were selected at random and tagged for assessing the physiological parameters. Observations were made during at 70, 90 and 105 DAS of the cotton crop.

- RLWC was estimated from the method suggested by Barrs and Weatherly (1962)and the result was expressed in percentage.

$$\text{RLWC (\%)} = \frac{\text{Leaf Fresh Weight} - \text{Leaf Dry Weight}}{\text{Leaf Turgid Weight} - \text{Leaf Dry Weight}} \times 100$$

- The leaf proline accumulation was estimated by Bates *et al*. (1973). The quantity of proline in the test sample was calculated with reference to the standard curve and expressed in terms of μmol g−1 FW.

- The seed cotton yield was obtained from net plot area was shade dried, weighed at each picking and yields of all picking were added and calculated as kg per plot and then expressed in kilogram per hectare. The data obtained were subjected to statistical analysis and were tested at five percent level of significance to interpret the treatment differences as suggested by Gomez. and Gomez, 2010.

Table 1: Effect of *Insitu* Water Harvesting and Stress Management Practices on RLWC (%) of Rainfed Cotton during *Rabi* 2017-18

Treatments	RWC (%)		
	70 DAS	90 DAS	105 DAS
***Insitu* Water Harvesting**			
Broad bed and furrow	80.7	80.1	74.9
Ridges and furrows	76.6	75.6	71.2
Compartmental bunding	73.0	71.4	67.4
S.Ed	1.58	1.40	1.46
CD (p=0.05)	4.39	3.99	4.08
Stress Management Practices			
Soil application of PH @ 5 kg ha^{-1}	74.6	72.5	68.8
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 1% KCl	78.5	79.7	73.0
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 5% Kaolin	77.5	77.7	74.2
Soil application of PH @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}	80.5	80.4	75.4
Soil application of PH @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm	76.5	74.6	70.3
Control	72.9	69.1	65.4
S.Ed	1.41	1.02	1.28
CD (p=0.05)	4.08	1.83	3.76
Interaction : I ×B			
S.Ed	3.53	1.78	3.22
CD (p=0.05)	NS	NS	NS

*****PH- Pusa hydrogel, PPFM-Pink Pigmented Facultative Methylobacteria

Table 2: Effect of *Insitu* Water Harvesting and Stress Management Practices on Leaf Proline Accumulation of Rainfed Cotton during *Rabi* 2017-18

Treatments	PROLINE (µmol g^{-1} FW)		
	70 DAS	90 DAS	105 DAS
***Insitu* Water Harvesting**			
Broad bed and furrow	5.88	7.50	5.72
Ridges and furrows	8.10	8.81	7.09
Compartmental bunding	10.32	10.13	8.47
S.Ed	0.18	0.39	0.24
CD (p=0.05)	0.77	1.66	1.04
Stress Management Practices			
Soil application of PH @ 5 kg ha^{-1}	8.53	10.15	8.25
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 1% KCl	7.55	7.55	5.90
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 5% Kaolin	7.55	7.77	6.25
Soil application of PH @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}	7.75	6.46	5.36
Soil application of PH @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm	6.85	9.11	7.65
Control	10.38	11.83	9.15
S.Ed	0.82	0.40	0.24
CD (p=0.05)	1.69	0.83	0.50
Interaction : I ×B			
S.Ed	1.09	0.65	0.40
CD (p=0.05)	NS	NS	NS

*****PH- Pusa hydrogel, PPFM-Pink Pigmented Facultative Methylobacteria

Table 3: Effect of *Insitu* Water Harvesting and Stress Management Practices on Seed Cotton Yield of Rainfed Cotton during *Rabi* 2017-18

Treatments	Seed Cotton Yield (kg/ha)
***Insitu* Water Harvesting**	
Broad bed and furrow	1,590
Ridges and furrows	1,467
Compartmental bunding	1,350
S.Ed	33
CD (P=0.05)	92
Stress Management Practices	
Soil application of PH @ 5 kg ha^{-1}	1,376
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 1% KCl	1,580
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 5% Kaolin	1,485
Soil application of PH @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}	1,786
Soil application of PH @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm	1,476
Control	1,109
S.Ed	30
CD (p=0.05)	72
Interaction : I ×B	
S.Ed	58
CD (p=0.05)	138

*****PH- Pusa hydrogel, PPFM-Pink Pigmented Facultative Methylobacteria

RESULTS AND DISCUSSIONS

Effect of *In-situ* Water Harvesting and Stress Management Practices on Physiological Parameters

Relative Leaf Water Content

In-situ water harvesting had profound influence on RLWC and registered higher values during the flowering (70 DAS) and comparatively less during the later stages of 90 and 105 DAS (Table 1). The earlier **7**0 DAS of cotton RLWC was higher under Broad bed and furrow(with 80.7 % and lower was recorded in Compartmental bunding with 73.0 %. The same trend was followed for the later stages of RLWC with Broad bed and furrow on 90 and 105 DAS with 80.1 and 74.9 respectively. The lower values were recorded under Compartmental bunding at 90 and 105 DAS with 71.4 and 67.4 % respectively. The observed significant decrease in RLWC under moisture stressed condition was due to reduced absorption of water from the soil and inability to control water loss through the stomata. Our results are in asserting the findings of Kumar *et al*. 2012, Ananthi*et al*. 2013.

Broad bed furrow system recorded higher RWC with respect to other land configurations. This was due to high soil moisture content at the root zone which increases the plant water status. The results are inconformity with Devaranavadgi and Santhana Bosu(2014).

Among the stress management practices with Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}recorded for the higher RLWC of 80.4 and 75.4 % at 90 and 105 DAS respectively. Which is comparable with Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of 1% KClat 90 and 105 DAS for RLWC.

In addition to this PPFM spray with that treatment release the osmo protectants (sugars and alcohols) on the surface of the plants. This matrix may help to protect the plants from desiccation and high temperatures (Madhaiyan*et al*., 2006).

Leaf Proline Accumulation

Water stress induces a significant decrease in metabolic factors such as the decrease in chlorophyll content and enhanced accumulation of proline (Din *et al.,* 2011). Accumulation of proline is a widespread plant response to environmental stress, including low water potential. Proline accumulation is believed to play adaptive roles in plant stress tolerance (Ashraf and Fooland, 2007).

When the moisture stress was getting high the proline levels also recorded high. Compartmental binding recorded for high levels of Proline in 70, 90 and 105 DAS with 10.32, 10.13 and 8.47μmol g^{-1} FW respectively (Table 2.). A minimum amount of proline was noticed with the road bed and furrow.

In the case of the stress management practices Soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}recorded for the lower levels of proline at 90 and 105 DAS. The accumulation of free proline in stressed plants has been found to be an adaptive mechanism for drought tolerance and a positive correlation between the magnitude of free proline accumulation. and drought tolerance has been considered as an index for determining drought tolerance potential of cultivars. In this study also moisture stressed treatments recorded the higher proline levels. This is in conformity with the findings of (Lobato*et al.,* 2008; Krishna prabu*et al*., 2016).

Effect of *In-situ* Water Harvesting and Stress Management Practices on Seed Cotton Yield

Moisture stress made significant yield differences between the treatments. Among *In-situ* water harvestingroad bed and furrow produced significantly higher seed cotton yield of 1590 kg/ha followed by Ridges and furrows and Compartmental binding which recorded yield of 1,467 and 1,350 kg ha^{-1}(Table 3.). Broad bed furrow system significantly influenced seed cotton yield as compared to other land configuration. The increment in yield is due to more soil moisture availability at the root zone particularly under subsurface level which favored better crop growth, more nutrient uptake and higher translocation leading to the production of larger leaf area index which was responsible for harvesting more so large energy that resulted in better crop growth yield and physiological components. In case of the stress management practices with soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}recorded for higher seed cotton yield 1,786 kg/ha.

In combination Broad bed and furrow and soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1} recorded higher seed cotton yield. This was evidenced from the values recorded for critical physiological characters, viz. RLWC and proline accumulation in leaf.

CONCLUSIONS

The higher RLWC indicates the better availability of water in the cell, which increases the photosynthetic rate, dry matter production, and high productivity. Also, the higher range of proline content in leaves was recorded under moisture stressed treatments, suggesting that the production of proline is probably a common response of crops under water-stressed condition. Combination road bed and furrow and soil application of push hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}for the better yield.

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